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HAVERSTOCK & OWENS LLP  
260 Sheridan Avenue, Suite 420  
Palo Alto, California 94306  
(650) 833-0160

NEW PATENT APPLICATION  
Assistant Commissioner for Patents  
Washington, D.C. 20231

Attorney Docket No.: LUCENT-01500

NEW APPLICATION TRANSMITTAL

Sir:

Transmitted herewith for filing is the patent application of Inventor: Chih-Yuan Chang et al.

Title: AN ADAPTIVE CELL SCHEDULING ALGORITHM FOR WIRELESS ASYNCHRONOUS TRANSFER MODE (ATM) SYSTEMS

CERTIFICATION UNDER 37 CFR § 1.10

I hereby certify that this New Application and the documents referred to as enclosed herein are being deposited with the United States Postal Service on this date, August 28, 2000, in an envelope bearing "Express Mail Post Office To Addressee" Mailing Label Number EL703161638US addressed to: **PATENT APPLICATION**, Assistant Commissioner for Patents, Washington, D.C. 20231.

Carleen O'Brien  
(Name of Person Mailing Paper)

[Signature]  
Signature

Enclosed are:

1. The papers required for filing date under CFR § 1.53(b):
  - 13 Pages of Specification (including claims); 2 Sheet(s) of Drawings.

X Formal  
   Informal
  - X Declaration or Oath (combined with Power of Attorney)
  - X Power of Attorney (combined with Declaration)
  - X Assignment of the Invention to Lucent Technologies, Inc. (including Form PTO-1595).
5. Fee Calculation
  - Amendment changing number of claims or deleting multiple dependencies is enclosed.

CLAIMS AS FILED

	Number Filed	Number Extra	Rate	Basic Fee
				\$690.00
Total Claims	41 - 20 =	21	\$18.00	378.00
Independent Claims	3 - 3 =	0	\$78.00	0.00
Multiple Dependent claim(s), if any			\$260.00	
Filing Fee Calculation				\$1,068.00

6. Other Fees
    - X Assignment Recordation Fee 40.00
    - Other 0.00
- TOTAL FEES ENCLOSED \$1,108.00**

7. X Please file the application and charge **Lucent Technologies Deposit Account No. 12-2325** the amount of \$1068.00 to cover the filing fee (\$1108.00) and the Assignment Recordation fee (\$40.00). Duplicate copies of this letter are enclosed. In the event of non-payment or improper payment of a required fee, the Commissioner is authorized to charge or credit **Deposit Account No. 12-2325** as required to correct the error.

8. X Return Receipt Postcard

9. X Please address all correspondence to  
Thomas B. Haverstock  
Haverstock & Owens LLP  
260 Sheridan Avenue, Suite 420  
Palo Alto, CA 94306

Dated: August 28, 2000

By: [Signature]  
Name: Thomas B. Haverstock  
Registration No.: 32,571

jc806 U.S. PTO  
09/649265  
08/28/00

PATENT

Attorney Docket No.: LUCENT-01500

**AN ADAPTIVE CELL SCHEDULING ALGORITHM FOR WIRELESS  
ASYNCHRONOUS TRANSFER MODE (ATM) SYSTEMS**FIELD OF THE INVENTION

This invention relates to the field of high speed wireless networks. More particularly, this invention relates to the field of integrating a scheduling algorithm to switch between contention and request and grant mode to achieve high performance in an asynchronous transfer mode (ATM) cell.

BACKGROUND OF THE INVENTION

The general structure of a high speed wireless network utilizes a central Hub and a number of End User Nodes (EUNs). The basic operating unit of the system is a cell, where the Hub is located at the center of the cell and the EUNs are distributed within the coverage range of the Hub. In the downstream direction (from the Hub to the EUNs), the communication channel is a broadcasting channel. In other words, any signal sent by the Hub is received by every EUN in the system.

In the upstream direction (from the EUNs to the Hub), each EUN transmission is a unicast heard only by the Hub. In a conventional high speed wireless network, the EUNs are not configured to receive transmissions from other EUNs. The upstream communication channel is shared by many EUNs using one of two types of access systems. A first access system is known as a time division multiple access (TDMA) based system is one in which all the EUNs transmit using the same frequency, but avoid colliding by transmitting at different times. A second access system is called a frequency division multiple access (FDMA) system is one in which each EUN has a separate frequency assignment to avoid collision when coordinating transmission. In both these access systems, the downstream signal is transmitted at a different carrier frequency than the upstream signal. However, because the upstream and downstream slots are of the same length, both channels have the same bandwidth.

As the EUNs are switched on, the Hub executes a one time ranging operation. Ranging determines the distance between each EUN and the Hub. An EUN which is far from the Hub must transmit faster than an EUN which is near to the Hub. After the

ranging is complete, the EUNs are accordingly aligned by the Hub in time slots from the frame of reference of the Hub.

During any given time slot, only one EUN is allowed to transmit at a time. To coordinate EUN transmission in a given time slot, the Hub may utilize one of two main coordinating modes.

A contention mode is utilized to coordinate transmission when there is a relatively small number of EUNs in the system trying to capture the upstream bandwidth. When there is a larger number of EUNs in the system, a request and grant, or piggybacking mode is used.

In the contention mode, the Hub broadcasts which EUNs are eligible to contend for a particular time slot. Each contending EUN will then answer the broadcast if that particular EUN wishes to transmit. This mode is particularly useful when there is a relatively small amount of EUNs in the system, or when idle EUNs require a route to request grants quickly.

The request and grant, or piggybacking mode functions oppositely of the contention mode. In the piggybacking mode, each individual EUN that wishes to transmit will unicast a request for a time slot from the Hub. The Hub will then broadcast a time slot grant signal to every EUN. When this occurs, each individual EUN will receive the signal and will recognize whether it, or another EUN is receiving a time slot grant. These grants will assign EUNs to time slots based on bandwidth availability. This mode is most effective when there are a large number of EUNs transmitting continuously.

Because the number of EUNs in a wireless system can change often and sometimes change in a short period of time, a scheduling algorithm is needed to adjust the ratio between request and grant mode and contention mode. To provide a smooth transition, an algorithm which can seamlessly switch between the two coordinating slotted multiple access modes is desired.

#### SUMMARY OF THE INVENTION

The present invention is a method of implementing an adaptive cell scheduling algorithm in a wireless network channel shared by a plurality of users. The present invention switches between two coordinating slotted multiple access modes to coordinate user transmission.

The two coordinating slotted multiple access modes, a contention mode and a request and grant mode, are both present in the network at all times and the percentage of each of the modes are dynamically changing values whose sum is always 100%.

The present invention allocates a queue in a weighted fair queue to generate contention slots. When a collision occurs between two users, two new requests for generating contention slots are placed in the weighted fair queue. When all contention is resolved, a starting request is placed in the weighted fair queue. This method allows the weighted fair queue to adjust the rate of generating contention slots automatically. When the network is lightly loaded, the weighted fair queue increases the rate of generating contention slots, and when the network is heavily loaded, the weighted fair queue decreases the rate of generating contention slots.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an ATM cube in a stack configuration of the present invention.

FIG. 2 illustrates a Multicast ID Table of the present invention.

FIG. 3 illustrates the preferred Scheduling Block of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the preferred embodiment of the present method, the basis for transmission of broadband information in this type of high speed wireless network is asynchronous transfer mode (ATM). An ATM Cube may be considered in terms of a traditional stack configuration as depicted in Figure 1. More specifically, the Hub receives ATM cells from a back-haul network and delivers them in a special format to the EUNs.

In the reverse direction, an EUN receives ATM cells from its subscribers or converts legacy interfaces to ATM and delivers these ATM cells in a special format to the Hub. The Hub recovers the ATM cells from the upstream signals and delivers them to the back-haul network.

Any ATM system may be considered in terms of the traditional layered protocol stack (Fig. 1). In this framework, the ATM Layer(10) is responsible for delivery of data across multiple physical connections. The ATM Adaption Layers (AALs)(12) and applications operate above the ATM Layer(10). Below the Network Layer, the ATM specification refers to a Physical Layer(PHY)(18). An ATM's PHY(18) consists of the

Transmission Convergence (TC) Sub-Layer(14) and the Physical Medium (PM). In terms of the traditional stack model, the TC is the Data Link Layer (DLL)(16) and the PHY(18) combined. In the traditional stack model, the DLL(16) is typically broken down into two sub-layers, a Logical Link Control (LLC), which interfaces to the network, and a MAC which interfaces to the PHY(18).

Referring again to Figure 1, an ATM system is also divided into vertical planes, which provide similar services in all protocol layers. These planes are the control, user, and management planes. The User Plane(22) is responsible for carrying data, including control and management information, across those connections and for performing functions such as flow control. The Control Plane(20) is responsible for performing call control and connection control functions. The Management Plane(24) is responsible for resource allocation, error and fault reporting, operation and maintenance (OAM) information flows, and any parameters associated with a given layer. In addition, an overall Layer Management(26) spans all layers and is responsible for the coordination of the entire system.

The preferred embodiment of the present method assigns each physical EUN a unique 6-byte physical identification that is used during sign-on. Thereafter, it is assigned a logical EUN\_ID from 1 to 254 (i.e. 0000\_0001 to 1111\_1110). The EUN\_ID is changeable on the fly and a physical EUN may be assigned multiple EUN\_IDs in order to allow it to have more than 256 Virtual Circuits (VCs). The link address is a 16 bit number, broken down into an 8 bit EUN\_ID, with an 8 bit sub-address. These bits can be used to specify a null, unicast or multicast/broadcast addresses.

According to the preferred embodiment of the present invention as depicted in Figure 2, multicast addressing is used for sending control messages and to assign contention slots. The multicast addresses use an EUN\_ID of 255 (1111\_1111). This form of addressing uses the 8 bit sub-addresses to specify a group of EUNs. As shown in Figure 2, a group may consist of all EUNs down to a specific EUN.

The upstream air interface of the preferred embodiment uses TDMA. Individual upstream slots are assigned to a specific VC in a specific EUN. Contention timeslots are assigned to a group of EUNs, using the multicast addressing mode. Since there is no retry mechanism, only cell requests may be transmitted in contention slots.

Two requests are included in each upstream burst in the MAC messaging field. Each request includes an 8 bit link layer connection (VCI) address (i.e. a link address without the EUN\_ID, which would be the same as that in the Link Address field), and an 8 bit length field, indicating the number of cells which are currently queued at the EUN. Because the actual length is transmitted, the effects of a lost or duplicated request are minimized.

The preferred embodiment of the invention also provides a contention mechanism to allow the EUN to notify the Hub of pending traffic. It is anticipated that the majority of the requests will be carried in normal MAC cells (piggybacking), but the contention mechanism provides a route for idle EUNs to request grants quickly. An upstream contention slot will be announced to all EUNs via a grant from the Hub using the multicast addressing mode, which indicates the group of EUNs that may contend.

The preferred embodiment of the present invention is depicted in Figure 3 and is configured to seamlessly switch between request and grant mode and contention mode. A scheduling algorithm incorporated by a scheduling block(30) containing a priority queue(32), a bypass queue(34), a weighted fair queue(36) and a contention queue(38) is used to implement this algorithm. The bypass queue(36) allows real time traffic such as Constant Bit Rate(CBR) to bypass the weighted fair queue(34) and not be included in the algorithm with the contention mode and the request and grant mode. Therefore, when the bypass queue(36) is not empty, the priority queue will allow the contents of the bypass queue(36) to be delivered before delivering the contents of the weighted fair queue(34).

Referring again to Figure 3, the weighted fair queue(36) actually implements the scheduling algorithm to serve non-real-time traffic classes so different streams such as EUN requests(40) and the output from the contention queue(38) can be prioritized based on their Quality of Service (QoS). The QoS is the priority given to any given EUN based upon the monetary value paid by that EUN to use the wireless network. For instance, an EUN that pays more in QoS will have a higher priority and therefore be higher in line than an EUN that pays less. The contention queue, however, has a priority lower than that of any EUN input(40) requesting bandwidth from the weighted fair queue(34).

Therefore, according to the preferred embodiment of the present invention, when the network is heavily loaded and a number of EUNs are requesting bandwidth(40) from the weighted fair queue(34), the contention queue(38) will occupy a small percentage of

the total requests to the weighted fair queue(34). For instance, if there are nine EUNs requesting bandwidth(40) from the weighted fair queue(34) in request and grant mode, the ratio of request and grant/contention will be 9/1 or 90% request and grant and 10% contention.

5           Referring again to Figure 3 in the preferred embodiment of the present invention, as the network becomes lightly loaded, the number of EUNs requesting bandwidth(40) from the weighted fair queue(34) decreases. However, the contention queue(38) retains the one input to the weighted fair queue(34). Therefore, as the number of EUNs requesting bandwidth(40) in the request and grant mode decreases, the ration of request and grant/contention decreases. For instance, if the number of EUNs requesting bandwidth(40) decreases to three, then the mode ration will be 3/1 or 75% request and grant and 25% contention. In other words, the percentage of contention in the system will seamlessly increase as the number of EUN requests(40) in the system decrease.

10           Alternative embodiments of the present invention include variations of the scheduler block(30) such as omissions, additions or reorganizations of the priority queue(32) or the bypass queue(36). However, the organization of the weighted fair queue(34), the contention queue(38) and the EUN requests(40) will not differ from the preferred embodiment.

15           Other aspects of the preferred embodiment of the present invention include the MAC continuously selecting cells to transmit in the downstream direction and assign upstream slots to specific VCs at specific EUNs. The downstream direction is straightforward, being very similar to existing wireline ATM systems. A Weighted Fair Queue (WFQ) is used for data traffic while the CBR traffic is transmitted immediately on a First In First Out (FIFO) basis.

20           Allocating the upstream bandwidth in the preferred embodiment is significantly more complicated. Each EUN sends requests to the Hub for specific VCs, which are carried with other upstream cells or vital to the contention mechanism. The Hub takes these requests and converts them into pseudo cells, which are input to an ATM scheduler. The Hub also predicts the arrival of CBR traffic, and generates pseudo cells for them automatically. To make each assignment, the Hub examines the virtual cell selected by the scheduler and grants an assignment to the corresponding VC at the appropriate EUN. Normally, requests are carried with other traffic in the request fields of upstream MAC

25           

30

cells. However, a contention mechanism is provided to significantly reduce latency when an otherwise idle EUN receives cells to transmit upstream.

5 The sign-on procedure of the preferred embodiment is used by an EUN to establish initial ranging and power adjustments and establish a MAC level connection with the Hub and is a variation of the standard ranging process as described in [Survey of Ranging and Calibration Algorithms, KA]. Following sign-on, the DLL performs authentication of the newly connected EUN and VCs. A standard sign-off procedure is provided to allow the Hub or a local operator to gracefully terminate an EUN's connection. A mechanism for detecting connection loss due to extreme RF conditions and algorithms to automatically reestablish the connection is provided.

10 It will be readily apparent to one skilled in the art that other various modifications may be made to the preferred embodiment without departing from the spirit and scope of the invention as defined by the appended claims.



CLAIMS

We claim:

1. A method of integrating a scheduling algorithm in a wireless network shared by a plurality of users comprising the step of utilizing an adaptive contention scheduling scheme.
2. The method of claim 1 wherein the adaptive contention scheduling scheme switches seamlessly between two coordinating slotted multiple access modes.
3. The method of claim 2 wherein both slotted multiple access modes are present in the wireless network at all times.
4. The method of claim 2 wherein a percentage value is assigned to each of the slotted multiple access modes.
5. The method of claim 4 wherein the sum of the percentage values is 100%.
6. The method of claim 4 wherein the percentage value for each slotted multiple access mode present in the wireless network is a dynamically changing value.
7. The method of claim 2 wherein the coordinating slotted multiple access modes include a request and grant mode and a contention mode.
8. The method of claim 1 wherein the adaptive contention scheduling scheme generates a plurality of contention slots.
9. The method of claim 8 wherein the adaptive contention scheduling scheme allocates a queue in a weighted fair queue for generating the plurality of contention slots.

3           10.           The method of claim 9 wherein two new requests for generating  
4 contention slots are placed in the weighted fair queue when a collision occurs between  
5 two users.

6           11.           The method of claim 10 wherein a starting request is placed in the  
7 weighted fair queue when all contention is resolved.

8           12.           The method of claim 9 further comprising utilizing the weighted fair  
9 queue to adjust the rate of generating the plurality of contention slots automatically.

10          13.           The method of claim 12 wherein the rate of generating the plurality of  
11 contention slots increases when the wireless network is lightly loaded.

12          14.           The method of claim 12 wherein the rate of generating the plurality of  
13 contention slots decreases when the wireless network is heavily loaded.

14          15.           An apparatus for integrating a scheduling algorithm in a wireless network  
15 shared by a plurality of users comprising means for implementing an adaptive contention  
16 scheduling scheme to switch seamlessly between two coordinating slotted multiple access  
17 modes.

18          16.           The apparatus of claim 15 wherein both coordinating slotted multiple  
19 access modes are present in the wireless network at all times.

20          17.           The apparatus of claim 15 wherein a percentage value is assigned to each  
21 of the slotted multiple access modes.

22          18.           The apparatus of claim 17 wherein the sum of the percentage values is  
23 100%.

24          19.           The apparatus of claim 17 wherein the percentage value for each slotted  
25 multiple access mode present in the wireless network is a dynamically changing value.

26           20.           The apparatus of claim 15 wherein the coordinating slotted multiple access  
27           modes include a request and grant mode and a contention mode.

28           21.           The apparatus of claim 15 wherein the adaptive contention scheduling  
29           scheme generates a plurality of contention slots.

30           22.           The apparatus of claim 21 wherein the adaptive contention scheduling  
31           scheme allocates a weighted fair queue for generating the plurality of contention slots.

32           23.           The apparatus of claim 22 wherein two new requests for generating  
33           contention slots are placed in the weighted fair queue when a collision occurs between  
34           two users.

35           24.           The apparatus of claim 23 wherein a starting request is placed in the  
36           weighted fair queue when all contention is resolved.

37           25.           The apparatus of claim 22 further comprising means for utilizing the  
38           weighted fair queue to adjust the rate of generating the plurality of contention slots  
39           automatically.

40           26.           The apparatus of claim 25 wherein the rate of generating the plurality of  
41           contention slots increases when the wireless network is lightly loaded.

42           27.           The apparatus of claim 25 wherein the rate of generating the plurality of  
43           contention slots decreases when the wireless network is heavily loaded.

1           28.           An apparatus for integrating a scheduling algorithm in a wireless network  
2           channel shared by a plurality of users comprising:

- 3           a.           a hub for transmitting and receiving wireless network signals  
4                       such that the hub may receive requests and assign portions of a  
5                       communication bandwidth;

- 6                   b.               a plurality of end user nodes for transmitting and receiving  
7 wireless network signals such that a plurality of users may request or be granted  
8 a portion of the communication bandwidth; and  
9                   c.               a weighted fair queue for utilizing an adaptive contention  
10 scheduling scheme to prioritize end user node requests and contention  
11 requests according to a quality of service standard.

12           29.           The apparatus of claim 28 wherein the adaptive contention scheduling  
scheme switches seamlessly between two coordinating slotted multiple access modes.

1           30.           The apparatus of claim 29 wherein both slotted multiple access modes are  
present in the wireless network at all times.

1           31.           The apparatus of claim 29 wherein a percentage value is assigned to each  
2 of the slotted multiple access modes.

3           32.           The apparatus of claim 31 wherein the sum of the percentage values is  
4 100%.

5           33.           The apparatus of claim 31 wherein a percentage value for each slotted  
multiple access mode present in the wireless network is a dynamically changing value.

1           34.           The apparatus of claim 29 wherein the coordinating slotted multiple access  
modes include a request and grant mode and a contention mode.

          35.           The apparatus of claim 28 wherein the adaptive contention scheduling  
scheme generates a plurality of contention slots.

1           36.           The apparatus of claim 35 wherein the adaptive contention scheduling  
2 scheme allocates a queue in the weighted fair queue for generating the plurality of  
3 contention slots.

4           37.           The apparatus of claim 36 wherein two new requests for generating  
5 contention slots are placed in the weighted fair queue when a collision occurs between  
6 two users.

7           38.           The apparatus of claim 37 wherein a starting request is placed in the  
8 weighted fair queue when all contention is resolved.

9           39.           The apparatus of claim 36 further comprising utilizing the weighted fair  
10 queue to adjust the rate of generating the plurality of contention slots automatically.

11          40.           The apparatus of claim 39 wherein the rate of generating the plurality of  
12 contention slots increases when the wireless network is lightly loaded.

13          41.           The apparatus of claim 39 wherein the rate of generating the plurality of  
14 contention slots decreases when the wireless network is heavily loaded.

ABSTRACT OF THE DISCLOSURE

A high speed wireless network for the access market where a scheduling algorithm adjusts the ratio of two contention modes used to allocate bandwidth from the Hub. The two contention modes, request and grant mode and contention mode, are utilized so that contention is greater when the system is lightly loaded and seamlessly decreases as the system becomes heavily loaded.

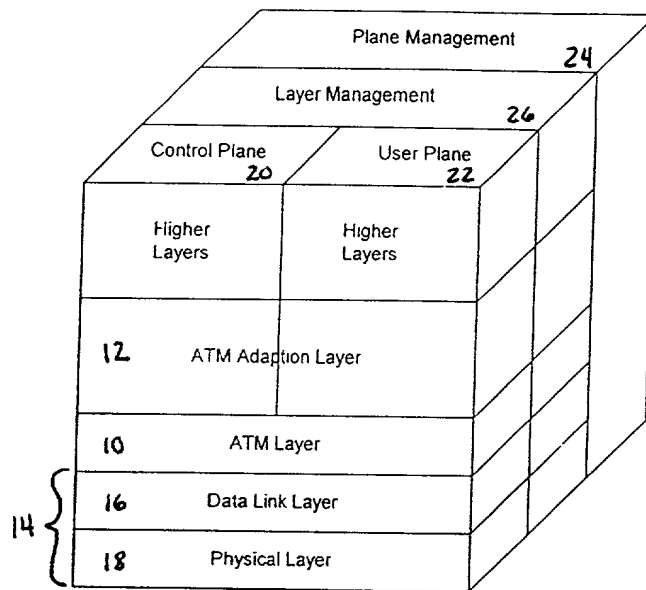


Figure 1 - ATM Cube

0PPP_PPPP	Group of 2 (xPPP_PPPP)
10PP_PPPP	Group of 4 (xxPP_PPPP)
110P_PPPP	Group of 8 (xxxP_PPPP)
1110_PPPP	Group of 16 (xxxx_PPPP)
1111_0PPP	Group of 32 (xxxx_xPPP)
1111_10PP	Group of 64 (xxxx_xxPP)
1111_110P	Group of 128 (xxxx_xxxP)
1111_1110	Group of 256 (xxxx_xxxx)

Figure 2 - Multicast ID

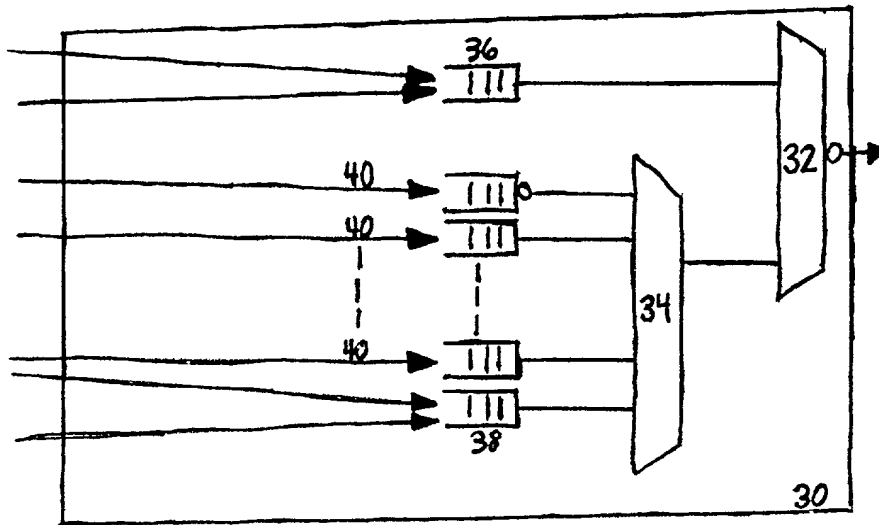


Figure 3 – Downstream scheduler



IN THE UNITED STATES  
PATENT AND TRADEMARK OFFICE

Declaration and Power of Attorney

As the below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **AN ADAPTIVE CELL SCHEDULING ALGORITHM FOR WIRELESS ASYNCHRONOUS TRANSFER MODE (ATM) SYSTEMS** the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to in this oath or declaration.

I acknowledge the duty to disclose all information known to me which is material to patentability as defined in Title 37, Code of Federal Regulations, 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

None

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

None

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

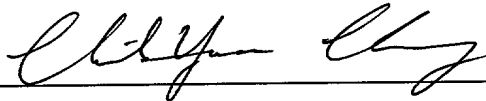
I hereby appoint the following attorney(s) with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith:

Thomas J. Bean	(Reg. No. 44528)
Lester H. Birnbaum	(Reg. No. 25830)
Richard J. Botos	(Reg. No. 32016)
Jeffery J. Brosemer	(Reg. No. 36096)
Kenneth M. Brown	(Reg. No. 37590)
Donald P. Dinella	(Reg. No. 39961)
Guy Eriksen	(Reg. No. 41736)
Martin I. Finston	(Reg. No. 31613)
William S. Francos	(Reg. No. 38456)
Barry H. Freedman	(Reg. No. 26166)
Julio A. Garceran	(Reg. No. 37138)
Jimmy Goo	(Reg. No. 36528)
Anthony Grillo	(Reg. No. 36535)
Stephen M. Gurey	(Reg. No. 27336)
John M. Harman	(Reg. No. 38173)
Matthew J. Hodulik	(Reg. No. 36164)
Michael B. Johannesen	(Reg. No. 35557)
Mark A. Kurisko	(Reg. No. 38944)
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John B. MacIntyre	(Reg. No. 41170)
Christopher N. Malvone	(Reg. No. 34866)
Scott W. McLellan	(Reg. No. 30776)
Martin G. Meder	(Reg. No. 34674)
John C. Moran	(Reg. No. 30782)
Michael A. Morra	(Reg. No. 28975)
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Neil R. Ormos	(Reg. No. 35309)
Eugen E. Pacher	(Reg. No. 29964)
Jack R. Penrod	(Reg. No. 31864)
Gregory C. Ranieri	(Reg. No. 29695)
Scott J. Rittman	(Reg. No. 39010)
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David L. Smith	(Reg. No. 30592)
Ozer M. N. Teitelbaum	(Reg. No. 36698)
John P. Veschi	(Reg. No. 39058)

David Volejnicek	(Reg. No. 29355)
Charles L. Warren	(Reg. No. 27407)
Jeffrey M. Weinick	(Reg. No. 36304)
Eli Weiss	(Reg. No. 17765)

I hereby appoint the attorney(s) on ATTACHMENT A as associate attorney(s) in the aforementioned application, with full power solely to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected with the prosecution of said application. No other powers are granted to such associate attorney(s) and such associate attorney(s) are specifically denied any power of substitution or revocation.

Full name of 1st joint inventor: Chih-Yuan (C.-Y. Chy)  
~~Chi-Yuan Chang~~

Inventor's signature  Date 8/1/2000

Residence: 3161 Ross Road, Palo Alto, CA 94303

Citizenship: Taiwan

Post Office Address: 3161 Ross Road, Palo Alto, CA 94303

Full name of 2nd joint inventor: Jenwei Liang

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 7459 De La Farge Drive, Cupertino, CA 95014

Citizenship: Taiwan

Post Office Address: 7459 De La Farge Drive, Cupertino, CA 95014

David Volejnicek	(Reg. No. 29355)
Charles L. Warren	(Reg. No. 27407)
Jeffrey M. Weinick	(Reg. No. 36304)
Eli Weiss	(Reg. No. 17765)

I hereby appoint the attorney(s) on ATTACHMENT A as associate attorney(s) in the aforementioned application, with full power solely to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected with the prosecution of said application. No other powers are granted to such associate attorney(s) and such associate attorney(s) are specifically denied any power of substitution or revocation.

Full name of 1st joint inventor: Chi-Yuan Chang

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 3161 Ross Road, Palo Alto, CA 94303

Citizenship: Taiwan

Post Office Address: 3161 Ross Road, Palo Alto, CA 94303

Full name of 2nd joint inventor: Jenwei Liang

Inventor's  
signature  \_\_\_\_\_ Date July 30, 2000

Residence: 7459 De La Farge Drive, Cupertino, CA 95014

Citizenship: Taiwan

Post Office Address: 7459 De La Farge Drive, Cupertino, CA 95014

Full name of 3rd joint inventor: Huei-ming Steve Yang

Inventor's  
signature Huei Ming Steve Yang Date 8/1/00

Residence: 4 Channel Drive, Redwood City, CA 94065

Citizenship: United States

Post Office Address: 4 Channel Drive, Redwood City, CA 94065

Full name of 4th joint inventor: Yee-Hsiang Chang

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 7771 Robindell Way, Cupertino, CA 95014

Citizenship: China

Post Office Address: 7771 Robindell Way, Cupertino, CA 95014

Full name of 5th joint inventor: Francis James Smith

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 877 Turino Street, Livermore, CA 94550

Citizenship: United States

Post Office Address: 877 Turino Street, Livermore, CA 94550

Full name of 3rd joint inventor: Huei-ming Steve Yang

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 4 Channel Drive, Redwood City, CA 94065

Citizenship: United States

Post Office Address: 4 Channel Drive, Redwood City, CA 94065

Full name of 4th joint inventor: Yee-Hsiang Chang

Inventor's  
signature Yee-Hsiang Chang Date 7/2/2000

Residence: 7771 Robindell Way, Cupertino, CA 95014

Citizenship: ~~China~~ TAIWAN

Post Office Address: 7771 Robindell Way, Cupertino, CA 95014

Full name of 5th joint inventor: Francis James Smith

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 877 Turino Street, Livermore, CA 94550

Citizenship: United States

Post Office Address: 877 Turino Street, Livermore, CA 94550

Full name of 3rd joint inventor: Huei-ming Steve Yang

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 4 Channel Drive, Redwood City, CA 94065

Citizenship: United States

Post Office Address: 4 Channel Drive, Redwood City, CA 94065

Full name of 4th joint inventor: Yee-Hsiang Chang

Inventor's  
signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: 7771 Robindell Way, Cupertino, CA 95014

Citizenship: China

Post Office Address: 7771 Robindell Way, Cupertino, CA 95014

Full name of 5th joint inventor: Francis James Smith

Inventor's  
signature  \_\_\_\_\_ Date 8/1/00

Residence: 877 Turino Street, Livermore, CA 94550

Citizenship: United States

Post Office Address: 877 Turino Street, Livermore, CA 94550

**ATTACHMENT A**

Attorney Name(s):	<u>Thomas B. Haverstock</u>	Reg. No.:	<u>32,571</u>
	<u>Jonathan O. Owens</u>		<u>37,902</u>
	<u>Lara L. Connors</u>		<u>42,432</u>

Telephone calls should be made to **HAVERSTOCK & OWENS LLP** at:

Phone No.: (650) 833-0160

Fax No.: (650) 833-0170

All written communications are to be addressed to:

**HAVERSTOCK & OWENS LLP**  
**260 Sheridan Avenue, Suite 420**  
**Palo Alto, CA 94306**